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KCooper
12.4.01
(RCE)

Attorney Docket No. 3600.100

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Reissue Application of	)	Examiner: C. Verdier
DAVID A. SPEAR ET AL.	)	Group Art Unit: 3745
Appln. No.: 09/343,736	)	
Filed: June 30, 1999	)	
For: SWEPT TURBOMACHINERY BLADE	)	Date: November 27, 2001

Commissioner for Patents
Washington, D.C. 20231

AMENDMENT AFTER FINAL REJECTION,
INFORMATION DISCLOSURE STATEMENT AND
SURRENDER OF ORIGINAL LETTERS PATENT

Sir:

In response to the Office Action of June 8, 2001, the time for responding to which having been extended to December 8, 2001, by the enclosed Petition for Extension of Time, please amend the above-identified application as follows:

Approved for Entry
CV
6/18/02

IN THE SPECIFICATION:

12/20/2001 KCOOPER1 00000001 09343736
02 FC:126

Immediately after the title, insert the following:

--CROSS REFERENCE TO RELATED REISSUE APPLICATIONS

This is the parent of a continuation reissue application filed on June 5, 2001, and accorded Application No. 09/874,931.

C1

STATEMENT REGARDING GOVERNMENT RIGHTS

The government has certain rights to this invention under Department of Defense Contract No. N00140-91-C-2793.--

IN THE CLAIMS:

Cancel claims 8, 12, 15, 18 and 24-26, without prejudice to submission of the subject matter thereof in a continuation application.

Rewrite reissue claims 4, 9-11, 16, 19-23, 27, 42, 43, 30 and 32, as follows:

4. A turbomachinery blade for a gas turbine engine fan comprising a plurality of blades mounted for rotation about a fan axis with neighboring blades forming passages for a working medium gas, wherein:

the blade has a configuration enabling the fan to rotate at speeds providing supersonic flow velocities over the blade in at least a portion of each passage causing the formation of a shock in the gas adjacent an inner wall of a case forming an outer boundary for the working medium gas flowing through the passages;

the blade has a leading edge with an inner region ending at an inward boundary of an intermediate region and a tip region

beginning at an outward boundary of the intermediate region and extending to a tip end of the blade, the inner region being swept forward and the intermediate region being swept rearward at a sweep angle that does not decrease; and

the tip region is translated forward relative to a leading edge with the same sweep angle as the outward boundary of the intermediate region, to provide a sweep angle that causes the blade to intercept the shock.

8 9. The turbomachinery blade of any one of claims 4 to 7, wherein the inner region extends between a root end of the blade and the inward boundary of the intermediate region, and the entire inner region is swept forward.

9 10. A blade for a gas turbine engine fan comprising a plurality of blades mounted for rotation within a case circumscribing the blades and forming an outer boundary for a working medium gas flowing through passages formed by neighboring blades, wherein:

the blade has a configuration enabling the fan to rotate at speeds providing supersonic flow velocities over the blade in at least a portion of each passage;

the blade has a leading edge with an inner region ending at an inward boundary of an intermediate region and a tip region

beginning at an outward boundary of the intermediate region and extending to a tip end of the blade, the inner region being swept forward and the intermediate region being swept rearward at a sweep angle that does not decrease from the inward boundary of the intermediate region to the outward boundary of the intermediate region; and

throughout the tip region the sweep angle is less than the sweep angle at the outward boundary of the intermediate region.

10 9
~~11.~~ The blade of claim ~~10~~, wherein the tip region is translated forward relative to a leading edge with the same sweep angle as the outward boundary of the intermediate region.

11 10
~~16.~~ The blade of claim ~~11~~, wherein the inner region extends between a root end of the blade and the inward boundary of the intermediate region, and the entire inner region is swept forward.

15 9
~~19.~~ The blade of claim ~~10~~, wherein the tip region maintains a rearward sweep throughout the tip region.

10
~~20.~~ A gas turbine engine fan, comprising a plurality of blades mounted for rotation within a case circumscribing the

blades and forming an outer boundary for a working medium gas flowing through passages formed by neighboring blades, wherein:

each blade has a configuration enabling the fan to rotate at speeds providing supersonic working medium gas velocities over the blade at least in the vicinity of the passages proximate to the case;

each blade has a leading edge with an inner region ending at an inward boundary of a swept intermediate region and a swept tip region beginning at an outward boundary of the intermediate region and extending to a tip end of the blade, the inner region of each blade being swept forward and the intermediate region of each blade being swept rearward at a sweep angle that does not decrease from the inward boundary of the intermediate region to the outward boundary of the intermediate region; and

throughout the tip region the sweep angle of each blade is less than the sweep angle at the outward boundary of the intermediate region.

17 16
21. The gas turbine engine fan of claim 20, wherein the tip region is translated forward relative to a leading edge with the same sweep angle as the outward boundary of the intermediate region.

18 17
~~22~~. The gas turbine engine fan of claim ~~21~~, wherein:

the intermediate region sweep angle of each blade increases throughout the intermediate region; and

the tip region sweep angle of each blade decreases throughout the tip region.

19 18
~~23~~. The gas turbine engine fan of claim ~~22~~, wherein the inner region of the leading edge of each blade begins at a root end of the blade and extends to the inward boundary of the intermediate region, and the entire inner region of each blade is swept forward.

20
~~27~~. A gas turbine engine fan comprising a plurality of identical blades, each blade being mounted for rotation within a case circumscribing the blades and having an inner wall forming an outer boundary for a working medium gas flowing through passages formed by neighboring blades, wherein:

each blade has a configuration enabling the fan to rotate at speeds providing supersonic working medium gas velocities over the blade in the vicinity of the passages proximate to the case;

each blade has a leading edge with an inner region, an intermediate region and a tip region, the inner region extending to an inward boundary of the intermediate region, and the tip

region extending from an outward boundary of the intermediate region to a tip end of the blade; and

the inner region is swept forward, the intermediate region is swept rearward at a sweep angle that does not decrease, and the tip region is translated forward relative to a leading edge with the same sweep angle as the outward boundary of the intermediate region.

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~~42.~~ The gas turbine engine fan of claim ~~27~~, wherein the inner wall of the case is perpendicular to pressure waves that extend spanwise of the blades as they rotate, the waves being incident to the case wall in a region of the blades.

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24 20
~~43.~~ The gas turbine engine fan of claim ~~27~~, wherein a projection of the tip end of each blade onto a radial plane is parallel to the inner wall of the casing in longitudinal cross-section.

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~~30.~~ A blade for a gas turbine engine rotatable within a case at speeds providing supersonic flow over at least a portion of the blade, wherein the blade has a leading edge with a forward swept inner region, the inner region ending at a rearward swept middle region having a sweep angle that does not decrease

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throughout the middle region, the middle region ending at a tip region that is translated forward relative to a leading edge with the same sweep angle as the end of the middle region.

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28 20
~~32~~. The blade of claim ~~30~~, wherein the inner region extends from a blade root to the middle region and the leading edge is swept forward throughout the inner region.

Add new dependent claim 44 shown below:

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25 20
~~44~~. The gas turbine engine fan of claim ~~27~~, wherein the inner region of the leading edge of each blade begins at a root end of the blade, and the entire inner region of each blade is swept forward.

REMARKS

The first addition to the specification is made pursuant to 37 C.F.R. § 1.177(a). This addition will also serve as notice to the Examiner under 37 C.F.R. § 1.178(b) of continuation Application No. 09/874,931.

The specification has also been amended to add a government rights statement.

Claims 8, 12, 15, 18 and 24-26 have been canceled and claims 4, 9-11, 16, 19-23, 27, 42, 43, 30 and 32 have been amended. New dependent claim 44 has been added. Claims 1-7, 9-11, 13, 14, 16, 17, 19-23 and 27-44 (37 total) are in the application. Claims 1, 2, 4, 10, 20, 27, 30 and 36 are independent.

The applicants note with appreciation the indication in the Office Action that the present application contains allowable subject matter. The claim changes herein are presented for the express purpose of placing the application in condition for allowance consistent with the indication in the Office Action that particular dependent claims were deemed patentable. Accordingly, the applicants believe that rejected independent claims 10, 20 and 30 are now allowable.

For the Examiner's convenience, attached Appendix A sets forth all of the new reissue claims remaining in the present application in the order it is believed they will be printed in the reissued patent. Changes made by the present amendment are shown underlined (additions) and bracketed (deletions).

The applicants believe the Examiner will be able to readily appreciate that the present Amendment places the application in condition for allowance, as explained below.

Starting with the rejection of dependent claim 43 under 35 U.S.C. § 112, second paragraph, as failing to particularly point

out and distinctly claim the subject matter regarded as the invention, the word "substantially" has been deleted from the claim. Although the applicants believe that the use of that word does not render the claim indefinite, they also believe that it is unnecessary to adequately protect the invention. It will be clear to those skilled in this art that the claim still covers arrangements in which the blade tip and casing wall are parallel to the extent possible, given manufacturing tolerances and operating conditions.

Turning to rejected independent claims 10, 20 and 30, the applicants took as their benchmark in amending these claims the Examiner's indication that dependent claim 32 recites allowable subject matter. That is, independent reissue claims 10, 20 and 30 have been amended according to the applicants' understanding of what the Examiner regarded as salient features of claim 32 leading to his indication that it recites allowable subject matter. (See also allowable dependent claims 16 and 23.)

The Examiner will note that all of claims 10, 20 and 30 now recite a forward swept inner region, a rearward swept intermediate or middle region, and a tip region with a leading edge that either is translated forward relative to a leading edge with the same sweep angle as the end of the intermediate (middle) region or throughout which the leading edge sweep angle is less than the sweep angle at the end of the intermediate region.

However, in amending rejected independent claims 10, 20 and 30 to place them in condition for allowance, the applicants have introduced one refinement to the feature taken from claim 32. Changes to allowed independent claims 4 and 27 incorporate the same refinement.

Specifically, the inner region of the blade is now recited in all of those claims in a manner that does not require forward sweep throughout the entire portion of the blade between the inward boundary of the intermediate (middle) region and the blade root.

This change has been introduced because the geometry of the flow path can actually result in a rearward sweep angle in an innermost portion of a fan blade. This can be appreciated by recalling that the sweep angle at any particular point on the blade depends on the orientation of the working medium velocity vector as it approaches the blade's leading edge. The specification, as well as papers previously submitted in the present application, describe this in detail.

To understand this point, consider that the hub fairing immediately upstream of the platform 20 shown in Figure 1 of the present application can define a flow boundary that causes the blade root to present a rearward sweep angle to the approaching working medium. That does not affect the rest of the blade (as recited in the claims in question) or the advantageous

arrangement whereby the blade leading edge has a forward swept inner region that transitions to a rearward swept intermediate or middle region. Accordingly, it is believed that this change in claim language does not affect the allowability of the claims.

In that connection, the applicants note that dependent claim 32, which the Examiner found allowable, simply recited "a forward swept inner region." It did not require that the entire portion of the blade from the root to the beginning of the middle region be swept forward. New language introduced into claims 4, 10, 20, 27 and 30 clarifies this aspect of the applicant's invention.

Since this new claim language is clearly supported by the present application, and captures a salient feature believed by the applicants to have led to the Examiner's decision that claim 32 was allowable, entry of these claim changes is respectfully requested even though the application is under final rejection.

New dependent claim 44, which is directed to the embodiment of the invention in which claim 27's forward swept inner region does extend to the blade root, relates to the same point. It is therefore believed to be allowable for the same reason. Changes to that effect have likewise been introduced to dependent claims 9, 16, 23 and 32.

Claim 20 has been further changed to make it clearer that it specifically relates to a gas turbine engine fan.

Another clarifying change to independent claims 4, 10, 20 and 27 adds that it is the flow velocity over the blade that is supersonic. This language is taken from claims 30 and 36, and is intended to clarify that the reference for measuring the flow velocity is the blade. Put another way, this clarifies that the flow is supersonic relative to the blade, as explained in the present specification. See, for example, page 3, lines 6-14. Since this terminology is borrowed from other claims where it was found unobjectionable, its introduction into claims 4, 10, 20 and 27 is believed not to present a new issue requiring substantive consideration by the Examiner.

Other claim changes and cancellations are made solely for the sake of consistency with other claim language and the changes discussed above. For example, the change in claims 4 and 42, by which the word "said" has been replaced by --the--, provides consistency with phraseology used in the other claims.

The applicants would like to make it clear that by making claim changes and canceling claims to place the present application in condition for allowance, they do not acquiesce in the rejection under 35 U.S.C. § 102 based on U.S. Patent 2,660,410 to Hull, Jr.

INFORMATION DISCLOSURE STATEMENT

The applicants also wish to notify the Examiner of the leading edge sweep angle profiles of fan blades from the PW305 and PW306 gas turbine engines of the assignee of the present invention. These profiles are plotted in the graph attached hereto as Appendix B. This information only recently came to light in connection with the present application.

The applicants would like to note that the submission of information regarding these two engines is not intended as an admission that they are in fact prior art to the present invention. Nor is the information submitted because it is necessarily believed to be material to the examination of the present application. Rather, it is submitted to place it before the Examiner so that he can confirm for himself the applicants' belief that it would not affect the patentability of the present claims even if it were prior art.

The applicants believe that the plots in Appendix B are largely self-explanatory. To assist the Examiner's consideration of them, the abscissa of the graph is the normalized blade span from root to tip (that is, the distance from the blade root divided by the total blade height). The ordinate is the aerodynamic sweep angle of each blade's leading edge, exactly as the term "sweep angle" is used in the applicants' claims. A

positive sweep angle (above zero on the ordinate) represents a rearward swept leading edge.

The Examiner will appreciate from a consideration of Appendix B that neither of the fan blades represented by the depicted plots of leading-edge profiles includes salient features of the present invention as represented by the claims now in the application. For example, neither has a leading edge with an intermediate region like that recited in the present claims in which the rearward sweep angle does not decrease from its beginning at an outward boundary of a forward swept inner region to its end at a translated forward tip region.

The enclosed Form PTO-1449 lists this information, and the Examiner is requested to initial the form and return it to the applicants to confirm that he considered the plots in Appendix B.

A check for $180 is enclosed to cover the fee required under 37 C.F.R. §§ 1.97(c)(2) and 1.17(p).

SURRENDER OF ORIGINAL LETTERS PATENT

As noted above, the applicants believe that the present case is in condition for allowance. Accordingly, original Letters Patent No. 5,642,985 is surrenered herewith pursuant to 37 C.F.R. § 1.178(a).

CONCLUSION

The applicants believe that this Amendment After Final Rejection, Information Disclosure Statement and Surrender of Original Letters Patent places the present application in condition for allowance.

Any fee associated with this paper not covered by amounts submitted herewith may be charged to Deposit Account No. 50-0409.

The applicants' undersigned attorney may be reached by telephone at (609) 921-8660. All correspondence should be directed to the below listed address.

Respectfully submitted,

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APPENDIX A TO AMENDMENT AFTER FINAL REJECTION

4. (Twice Amended) A turbomachinery blade for a gas turbine engine fan comprising a plurality of blades mounted for rotation about a fan axis with neighboring blades forming passages for a working medium gas, wherein:

the blade has a configuration enabling the fan to rotate at speeds providing supersonic flow velocities over the blade in at least a portion of each passage causing the formation of a shock in the gas adjacent an inner wall of a case forming an outer boundary for the working medium gas flowing through the passages;

the blade has a leading edge with an inner region ending at an inward boundary of an intermediate region and a tip region beginning at an outward boundary of the intermediate region and extending to a tip end of the blade, the inner region being swept forward and the intermediate region being swept rearward at a sweep angle that does not decrease; and

the tip region is translated forward relative to a leading edge with the same sweep angle as the outward boundary of the [said] intermediate region, to provide a sweep angle that causes the blade to intercept the shock.

5. (Previously Amended) The turbomachinery blade of claim 4, wherein throughout the tip region the sweep angle is less than the sweep angle at the outward boundary of the intermediate region.

6. (As Filed) The turbomachinery blade of claim 5, wherein the sweep angle decreases throughout the tip region.

7. (As Filed) The turbomachinery blade of claim 6, wherein the sweep angle increases throughout the intermediate region.

8. (Canceled)

9. (Amended) The turbomachinery blade of any one of claims 4 to 7, wherein the [leading edge of the blade has an] inner region extends between [beginning at] a root end of the blade and the [extending to an] inward boundary of the intermediate region, and the entire inner region is [being] swept forward.

10. (Twice Amended) A blade for a gas turbine engine fan comprising a plurality of blades mounted for rotation within a

case circumscribing the blades and forming an outer boundary for a working medium gas flowing through passages formed by neighboring blades, wherein:

the blade has a configuration enabling the fan to rotate at speeds providing supersonic flow velocities over the blade in at least a portion of each passage;

the blade has a leading edge with an inner region ending at an inward boundary of an intermediate region and a tip region beginning at an outward boundary of the intermediate region and extending to a tip end of the blade, the inner region being swept forward and the intermediate region being swept rearward at [having] a sweep angle that does not decrease from the [an] inward boundary of the intermediate region to the outward boundary of the intermediate region; and

throughout the tip region the sweep angle is less than the sweep angle at the outward boundary of the intermediate region.

11. (Twice Amended) The blade of claim 10, wherein [the intermediate region is swept rearward and] the tip region is translated forward relative to a leading edge with the same sweep angle as the outward boundary of the intermediate region.

12. (Canceled)

13. (As Filed) The blade of claim 10, wherein the tip region sweep angle decreases throughout the tip region.

14. (As Filed) The blade of claim 13, wherein the intermediate region sweep angle increases throughout the intermediate region.

15. (Canceled)

16. (Twice Amended) The blade of claim 11 [10], wherein [: the intermediate region is swept rearward and the tip region is translated forward relative to a leading edge with the same sweep angle as the outward boundary of the intermediate region; and the leading edge of the blade has an] the inner region extends between [beginning at] a root end of the blade and [extending to] the inward boundary of the intermediate region, and the entire inner region is [being] swept forward.

17. (As Filed) The blade of claim 16, wherein:

the intermediate region sweep angle increases throughout the intermediate region; and

the tip region sweep angle decreases throughout the tip region.

18. (Canceled)

19. (Amended) The blade of claim 10 [18], wherein the tip region maintains a rearward sweep throughout the tip region.

20. (Twice Amended) A [Turbomachinery for a] gas turbine engine fan, comprising a plurality of blades mounted for rotation within a case circumscribing the blades and forming an outer boundary for a working medium gas flowing through passages formed by neighboring blades, wherein:

each blade has a configuration enabling the fan [turbomachinery] to rotate at speeds providing supersonic working medium gas velocities over the blade at least in the vicinity of the passages proximate to the case;

each blade has a leading edge with an inner region ending at an inward boundary of a swept intermediate region and a swept tip region beginning at an outward boundary of the intermediate region and extending to a tip end of the blade, the inner region of each blade being swept forward and the intermediate region of each blade being swept rearward at [having] a sweep angle that does not decrease from the [an] inward boundary of the intermediate region to the outward boundary of the intermediate region; and

throughout the tip region the sweep angle of each blade is less than the sweep angle at the outward boundary of the intermediate region.

21. (Twice Amended) The gas turbine engine fan [turbomachinery] of claim 20, wherein [the intermediate region of each blade is swept rearward and] the tip region is translated forward relative to a leading edge with the same sweep angle as the outward boundary of the intermediate region.

22. (Amended) The gas turbine engine fan [turbomachinery] of claim 21, wherein:

the intermediate region sweep angle of each blade increases throughout the intermediate region; and

the tip region sweep angle of each blade decreases throughout the tip region.

23. (Twice Amended) The gas turbine engine fan [turbomachinery] of claim 22, wherein the inner region of the leading edge of each blade begins [has an inner region beginning] at a root end of the blade and extends [extending] to an [the] inward boundary of the intermediate region, and the entire inner region of each blade is [being] swept forward.

24. (Canceled)

25. (Canceled)

26. (Canceled)

27. (Twice Amended) A gas turbine engine fan comprising a plurality of identical blades, each blade being mounted for rotation within a case circumscribing the blades and having an inner wall forming an outer boundary for a working medium gas flowing through passages formed by neighboring blades, wherein:

each blade has a configuration enabling the fan to rotate at speeds providing supersonic working medium gas velocities over the blade in the vicinity of the passages proximate to the case;

each blade has a leading edge with an inner region, an intermediate region and a tip region, the inner region [beginning at a root end of the blade and] extending to an inward boundary of the intermediate region, and the tip region extending from an outward boundary of the intermediate region to a tip end of the blade; and

the inner region is swept forward, the intermediate region is swept rearward at a sweep angle that does not decrease, and the tip region is translated forward relative to a leading edge

with the same sweep angle as the outward boundary of the intermediate region.

28. (As Filed) The gas turbine engine fan of claim 27, wherein the tip region maintains a rearward sweep throughout the tip region.

29. (As Filed) The gas turbine engine fan of claim 27, wherein:

the intermediate region sweep angle of each blade increases throughout the intermediate region; and

the tip region of each blade is swept at a sweep angle that decreases throughout the tip region.

42. (Amended) The gas turbine engine fan of claim 27, wherein the inner wall of the case is perpendicular to pressure waves that extend spanwise of the blades as they rotate, the [said] waves being incident to the case wall in a region of the blades.

43. (Amended) The gas turbine engine fan of claim 27, wherein a projection of the tip end of each blade onto a radial

plane is [substantially] parallel to the inner wall of the casing in longitudinal cross-section.

44. (New) The gas turbine engine fan of claim 27, wherein the inner region of the leading edge of each blade begins at a root end of the blade, and the entire inner region of each blade is swept forward.

30. (Twice Amended) A blade for a gas turbine engine rotatable within a case at speeds providing supersonic flow over at least a portion of the blade, wherein the blade has a leading edge with a forward swept inner region, the inner region ending at a rearward swept middle region having a sweep angle that does not decrease throughout the middle region, the middle region ending at a tip region that is translated forward relative to a leading edge with the same sweep angle as the end of the middle region.

31. (As Filed) The blade of claim 30, wherein the tip region maintains a rearward sweep throughout the tip region.

32. (Amended) The blade of claim 30, wherein the inner region extends from a blade root to the middle region and the

leading edge is swept [has a] forward throughout the [swept] inner region.

33. (As Filed) The blade of claim 32, wherein the sweep angle of the middle region increases throughout the middle region.

34. (As Filed) The blade of claim 33, wherein throughout the tip region the sweep angle is less than the sweep angle at the end of the middle region.

35. (As Filed) The blade of claim 34, wherein the sweep angle of the tip region decreases from the end of the middle region to a tip end of the blade.

36. (Previously Amended) A blade for a gas turbine engine rotatable within a case at speeds providing supersonic flow over at least a portion of the blade, wherein the blade has a leading edge with a forward swept middle region having a sweep angle that does not decrease throughout the middle region and ending at a tip region that is translated rearward relative to a leading edge with the same sweep angle as the end of the middle region.

37. (As Filed) The blade of claim 36, wherein the tip region maintains a forward sweep throughout the tip region.

38. (As Filed) The blade of claim 36, wherein the leading edge has a rear swept inner region.

39. (As Filed) The blade of claim 38, wherein the sweep angle of the middle region increases throughout the middle region.

40. (As Filed) The blade of claim 39, wherein throughout the tip region the sweep angle is less than the sweep angle at the end of the middle region.

41. (As Filed) The blade of claim 40, wherein the sweep angle of the tip region decreases from the end of the middle region to a tip end of the blade.